ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: FHWA-AZ-8604

CRACK AND SEAT CONCRETE PAVEMENT

Construction Report

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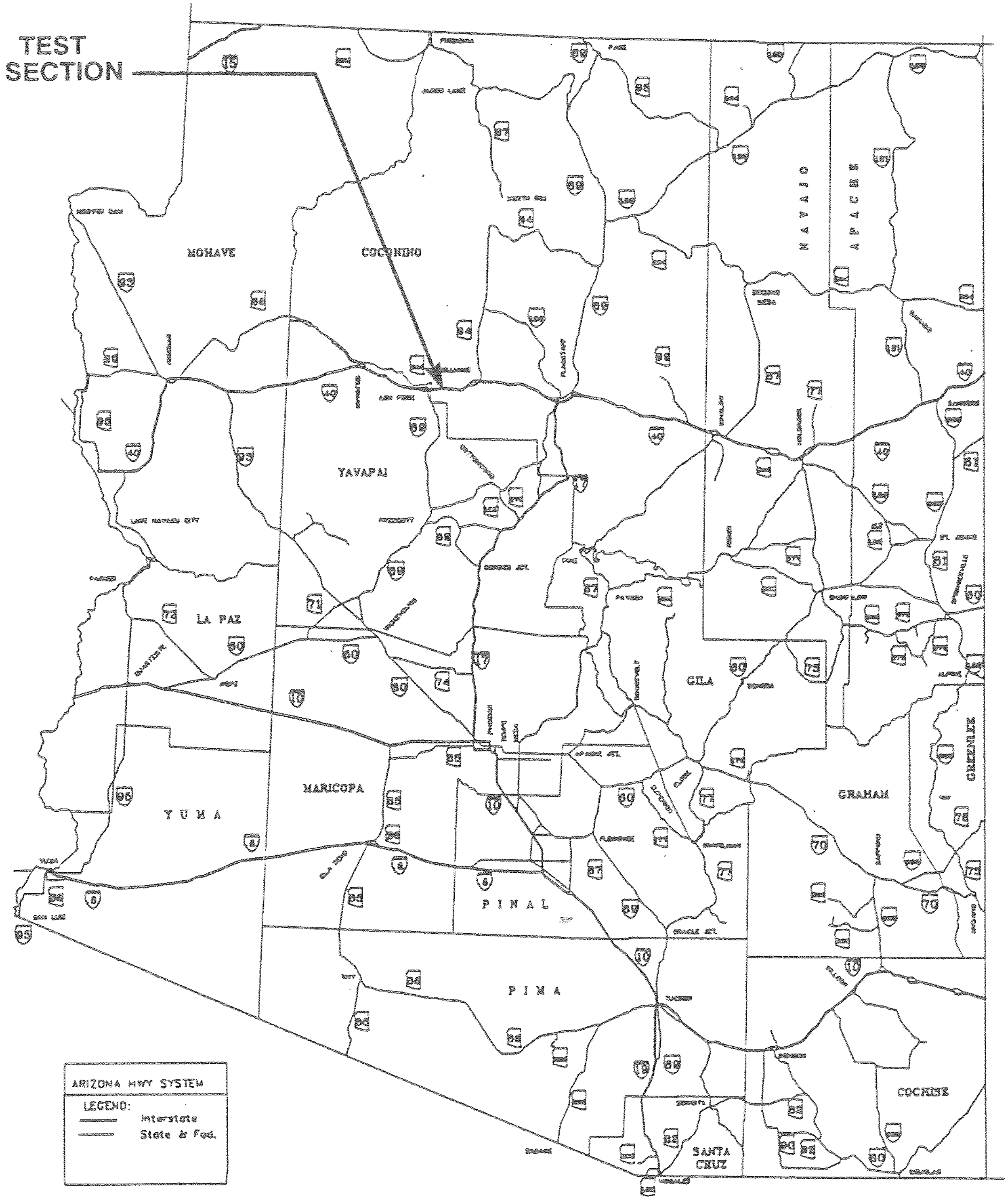
September 1987

Prepared for:

Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007
in cooperation with
U.S. Department of Transportation
Federal Highway Administration



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TECHNICAL REPORT DOCUMENTATION PAGE

1. REPORT NO. FHWA-AZ8604	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE CRACK AND SEAT CONCRETE PAVEMENT		5. REPORT DATE September 1987 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Abdallah H. Osseiran		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Arizona Department of Transportation 206 S. 17th Avenue Phoenix, Arizona 85007		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO. HPR-PL-1(33) ITEM 114
12. SPONSORING AGENCY NAME AND ADDRESS ARIZONA DEPARTMENT OF TRANSPORTATION 206 S. 17TH AVENUE PHOENIX, ARIZONA 85007		13. TYPE OF REPORT & PERIOD COVERED Construction Report October, 1986 - June, 1987 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration

16. ABSTRACT

Prevention of reflective cracking in HMAC overlays placed over PCCP has been based on experience gained from trial and error methods of in-service pavements in many states.

Arizona receltly utilized this technique on a PCCP section of Interstate 40 between MP 152.1 and MP 158.6 EB and WB prior to placing a 4 inch HMAC overlay. Two sections, 500' in length, were cracked and seated on the WB roadway using 2 ft. x 2 ft. and 4 ft. x 6 ft. patterns, respectively. The remaining six miles of project IR-40-3(59)C were cracked and seated using a 3ft. x 3 ft. pattern for both the EB and WB roadways.

A Michigan whiphammer was used for cracking the pavement and a fifty ton pneumatic roller used for seating it. Visual identification of the cracking was difficult, but indicated a spider-web like crack pattern has been produced.

The project, constructed in the fall of 1986, will be evaluated by ADOT annually for five years as Project AZ8604. The evaluation of this construction experimental feature will document the performance of the crack and seat technique and the effects of varying the crack pattern

A nine month evaluation is inclued with the construction report.

17. KEY WORDS Crack and Seat, Pavement, Reflective Cracks, Joints, Drainage, Overlay, Hot Mix Asphalt Concrete	18. DISTRIBUTION STATEMENT Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. SECURITY CLASSIF. (of this report) Unclassified	20. SECURITY CLASSIF. (of this page) Unclassified	21. NO. OF PAGES 61	22. PRICE

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A. Background and Problem Statement

Portland Cement Concrete Pavements (PCCP) are often rehabilitated by overlaying with asphalt concrete. Even when special care is taken, reflective cracks will often occur in the overlay at locations matching the transverse joints and existing cracks of the underlying concrete. In some instances, once the cracks have developed and stress is relieved in the overlay, little further deterioration occurs. However, in the majority of cases, the cracked areas continue to deteriorate. The combination of water infiltration, change in temperature, and traffic leads to raveling and crumbling of the overlay. Vertical movement at slab joints and cracks can be caused by lack of subgrade support, voids under the slabs, frost action, and soft or wet subgrades. Consequently, maintenance measures become ineffective and the overlay's service life is shortened considerably.

Cracking and seating of the PCCP is the process of cracking the pavement into smaller-than-joint-length pieces and rolling the area to seat the pavement against the subgrade. This process is used in an effort to prevent or delay the reflection of cracking through the asphalt overlay.

Many states have tested various methods of reducing reflective cracking: New York experimented with mesh reinforcement and stone-dust bond and sawing; California experimented with fabrics and open-graded interlayer; Virginia experimented with sand-bond breaker and high strength fabrics. Some of these treatments worked well and some failed. New York and California also experimented with the cracking and seating of PCCP.

Reports from those states demonstrated that the crack and seat works well for certain crack patterns, but works poorly for others.

Unit costs of various reflection crack control methods are as follows:

Method	***cost per square Yard of Pavement**
Cracking and Seating	$ 0.20 - 1.00
One-inch Hot Mix Asphalt Overlay	$ 1.40 - 1.80
Engineering fabric	$ 1.00 - 1.50
Four-inch asphalt-treated open graded interlayer	$ 5.50 - 7.00
Six-inch granular base course interlayer	$ 1.00 - 3.00
Stress absorbing membrane	$ 1.00 - 1.20
Sawing and sealing Hot Mix Asphalt at 40-foot intervals	$ 0.80 - 1.30
Four-foot width joint reconstruction at 80-foot intervals	$ 2.50 - 3.00

* Reference No. 7

Arizona's past experience with reflective crack treatment includes the use of an asphalt-rubber stress absorbing membrane placed between the PCCP and the asphalt concrete overlay, fabric interlayers, fibrous additives in the hot mix asphalt concrete (HMAC) , sawing and sealing, and a break and seat project in 1970.

B. Objective

Due to Arizona's limited experience with the crack and seat rehabilitation techniques the FHWA and ADOT agreed to an experimental construction project. The objective was to evaluate the constructability and long term field performance of several crack spacings. It is anticipated that the long term monitoring of these sections will provide additional insight into the effectiveness of the crack and seat process applied in Arizona.

This experimental project is located on Interstate 40 near Williams, Arizona (See Appendix A for vicinity map) and consists of four sections:

1) Between MP 152.1 & 152.2 West Bound(WB); spacing pattern 6'X4'
2) Between MP 152.2 & 152.3 WB; spacing pattern 2'X2'
3) Between MP 152.3 & 158.6 WB; spacing pattern 3'X3'
4) Between MP 152.1 & 158.6 East Bound(EB); spacing pattern 3'X3'

The test sections for this project are the 2'X2' & the 4'X6' sections. The Arizona Transportation Research Center (ATRC) will monitor this project for five years. There was no standard or control section in this project, i.e., HMAC overlaying a non-cracked PCCP, to compare the cracked and seated sections against.

II. Factors of Influence on the Success of Crack and Seat

A number of factors influence the technique of cracking and seating:

A. Existing Pavement Characteristics:

The characteristics of a pavement determines the required impact energy for a particular cracking pattern. Such characteristics include the strength of the slab, joint spacing, extent of damage or disintegration, and joint condition.

The pavement section for both the east and west bound directions consisted of 6" subgrade seal, 4" of cement treated base and an 8" portland cement concrete. The west bound was constructed in July, 1967, while the east bound was constructed in July, 1968. The concrete used for the PCCP was tan in color in the WB direction, while it was gray in the east bound direction. This difference in color is due to the difference in aggregates types.

The PCCP for this project was constructed of 4000 psi concrete (class P) with joints spaced at 15' intervals. Joint faulting averaged 40% in travel lanes and 15% in passing lanes. The average faulting (difference in elevation across a joint or crack) was 1/4" with a maximum of 3/8". The severity level of such faulting is considered to be medium according to the Highway Pavement Distress Identification Manual.

Spalls were frequently seen throughout the project and some cracks were found to be as wide as 1". Although the joints were sealed, the sealant was loose and had separated from the joints. Many of the broken slabs had not been sealed. The slabs which were sealed, however, appeared to have been oversealed. This is visible in Figures 1 and 2. Aside from the cracks and the faults, the concrete pavement had only a few areas patched with asphalt concrete.

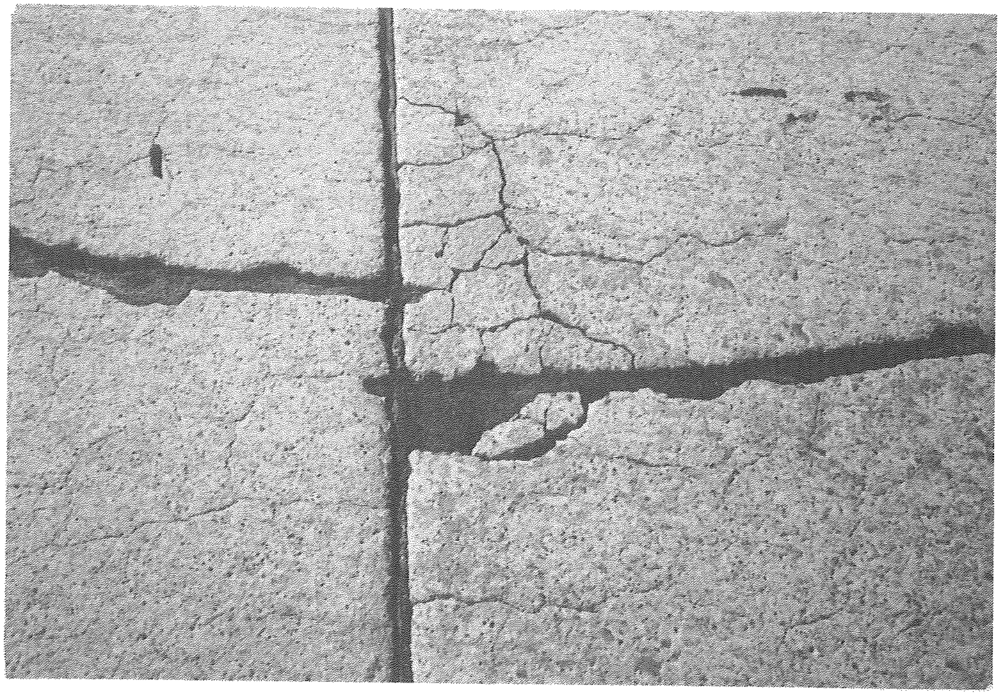


Figure 1. Typical Severe Cracking of the PCCP Near Joints

Figure 2 Typical Block Cracking of the PCCP

Mu-Meter testing indicated that the average friction numbers for the EB lanes in 1984 was 49, with a low of 33 at MP 152. The average friction number for the WB lanes in 1984 was 52 which is in the good range with a low of 30 at MP 158. The average Mu-Meter values in 1983 were 51 and 44 for WB and EB respectively.

Mays meter tests indicate a gradual increase in roughness in recent years. The average Mays roughness at MP 152 between the years 1978 and 1984 was 327 and 168 for the EB and the WB lanes respectively.

Dynaflect deflection tests were performed in September 1984. Table 1 below shows results of the Dynaflect deflection tests conducted at MP 152 WB for the travel and passing lanes. Areas with cracked slabs appeared noticeably weaker at the joints than non-cracked areas.

Table 1 Dynaflect Deflection Tests at MP 152 WB

	Driving Lane					Passing Lane					Spreadability
	Sensor #					Sensor #					
	1	2	3	4	5	1	2	3	4	5	55%
Mean Deflection (mills)	1.08	0.84	0.48	0.22	0.08	0.66	0.65	0.34	0.21	0.09	

Twenty seven soil samples were collected at different locations between MP 152 and MP 159. The soil ranged from gravel (GP) to clay (CH) with plasticity index ranging from NP to 38. Presence of cinders, sands, and silty sands was also reported (copies of the subgrade data are in Appendix E). R-value ranged from 8 to 88 with an average value of 59. The modulus of subgrade reaction (K-value) had an average value of 846 pounds per cubic inch. Moisture content determination indicated that in most areas it was below the optimum moisture content.

B. Cracking Process and Size of the Cracked Pieces:

The cracking of the PCCP was accomplished using a whiphammer (Figure 3). The whiphammer utilized a centrally mounted impact device which was thrown against the pavement with a whip-like action impacting the pavement with a rectangular foot print (typical dimensions of approximately 4.5" x 7.0"). The special provisions specified cracking patterns of 3'x 3', 4'x 6' and 2' x 2' (See Appendix B for a copy of the special provisions).

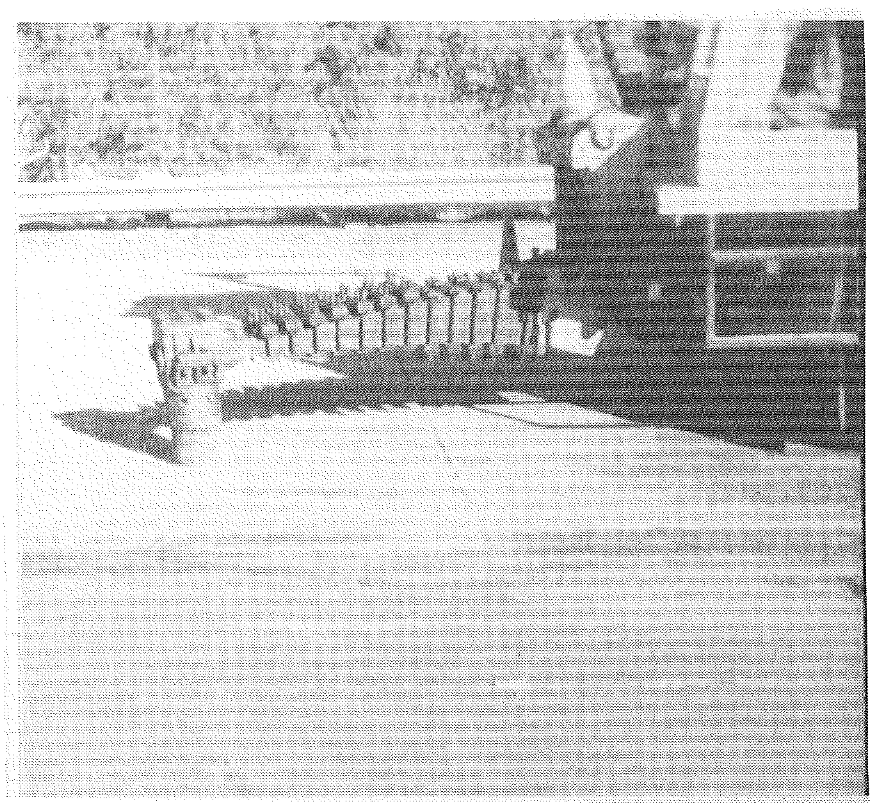


Figure 3 The Whiphammer Used for Cracking the PCCP

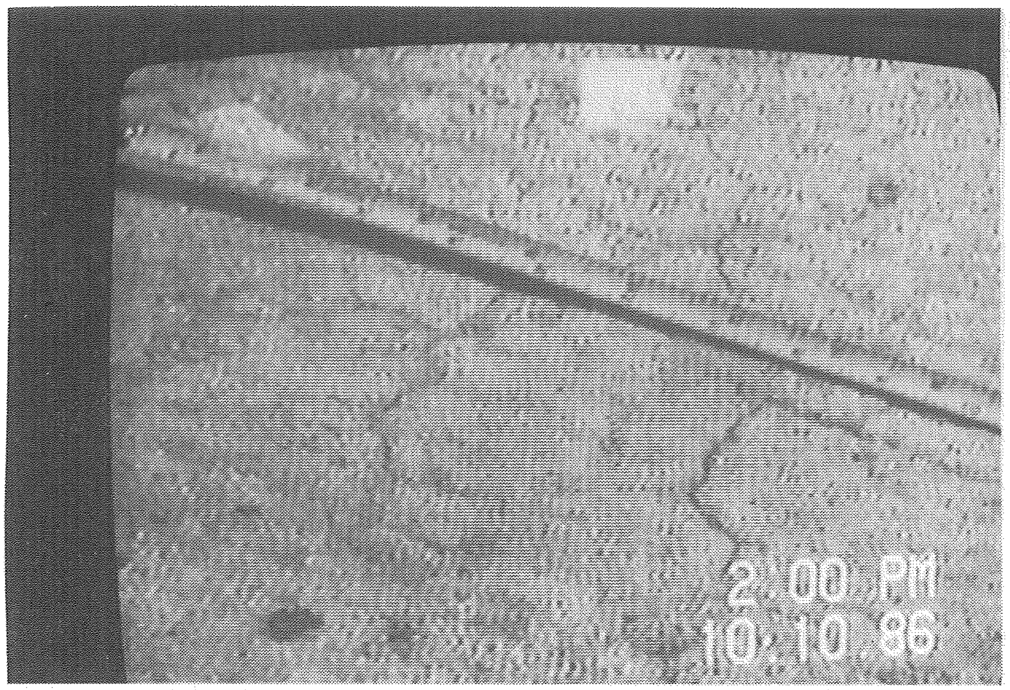


Figure 4 Typical Cracking Pattern of the Whiphammer

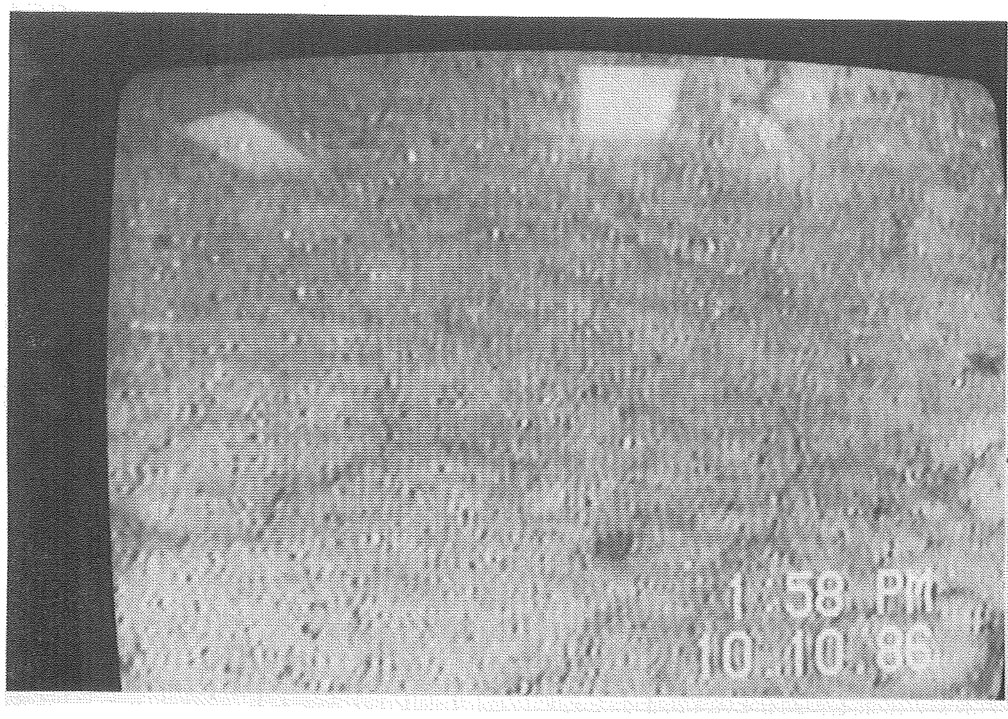
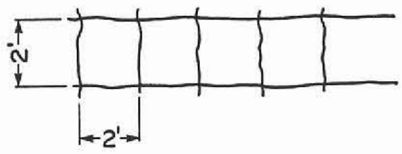
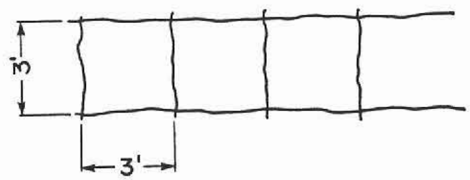


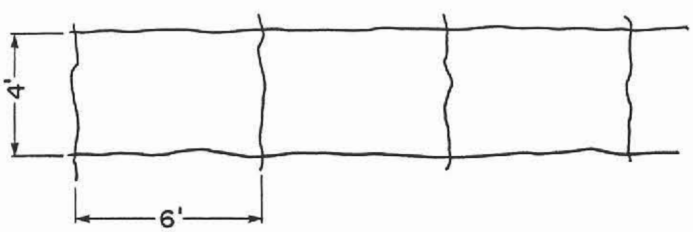
Figure 5 Typical Cracking Pattern of the Whiphammer



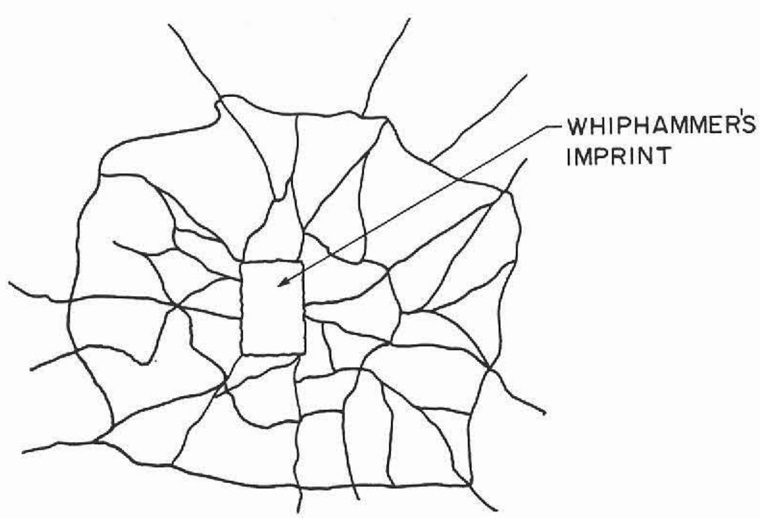
EXPECTED 2' x 2' CRACKING PATTERN



EXPECTED 3' x 3' CRACKING PATTERN



EXPECTED 4' x 6' CRACKING PATTERN



TYPICAL "SPIDER WEB" CRACKING PATTERN
PRODUCED BY THE WHIPHAMMER

Figure 6 Rendering of the Expected and the Produced Cracking Pattern

The size of the cracked pieces ranged between four and nine square feet. The cracked pieces were generally not square but were usually diamond or triangular in shape. A "Spider web" type of cracking pattern was produced by the Whiphammer. The cracks were not visually detectable on a dry pavement; therefore the pattern was checked periodically by applying water to the cracked surface so that the cracks could be more readily detected. Figures numbered 4 and 5 show a typical cracked PCCP. Figure 6 shows a rendering of the expected and the produced cracking pattern. Cores, randomly taken, verified that the hairline cracks penetrated the full depth of the slab (Figure 7).

The whiphammer was capable of operating at a rate of 2000 sq. ft/hr;however, the machine was not operated at this rate because other construction features limited its production. To establish the specified cracking patterns, varying energy and striking patterns were used until a satisfactory cracking pattern was established. Also different heads, on the Whiphammer were tried. This was not a difficult or time consuming task and was necessary as each concrete was different.

With all cracking equipment, care should be exercised when working near joints and edges to avoid spalling or longitudinal cracking. During the cracking operation the whiphammer was not allowed to strike the slabs within one foot of a joint or edge. The cracks were generally at a skew to the longitudinal joint.

The cracking process is designed to break the slab into smaller sections in order to reduce localized horizontal movements.

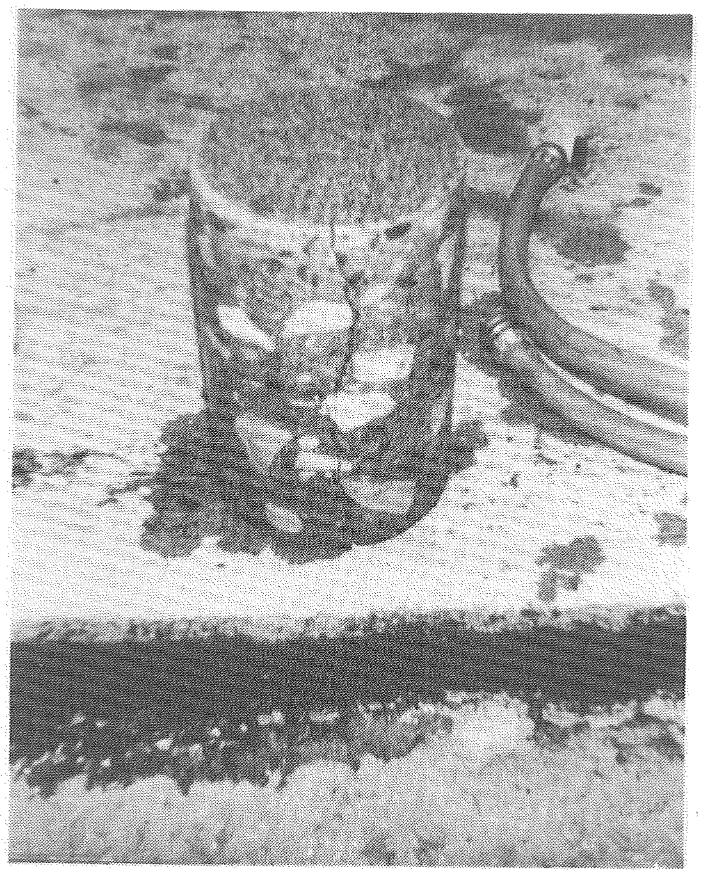


Figure 7 Core Thru the Cracked PCCP

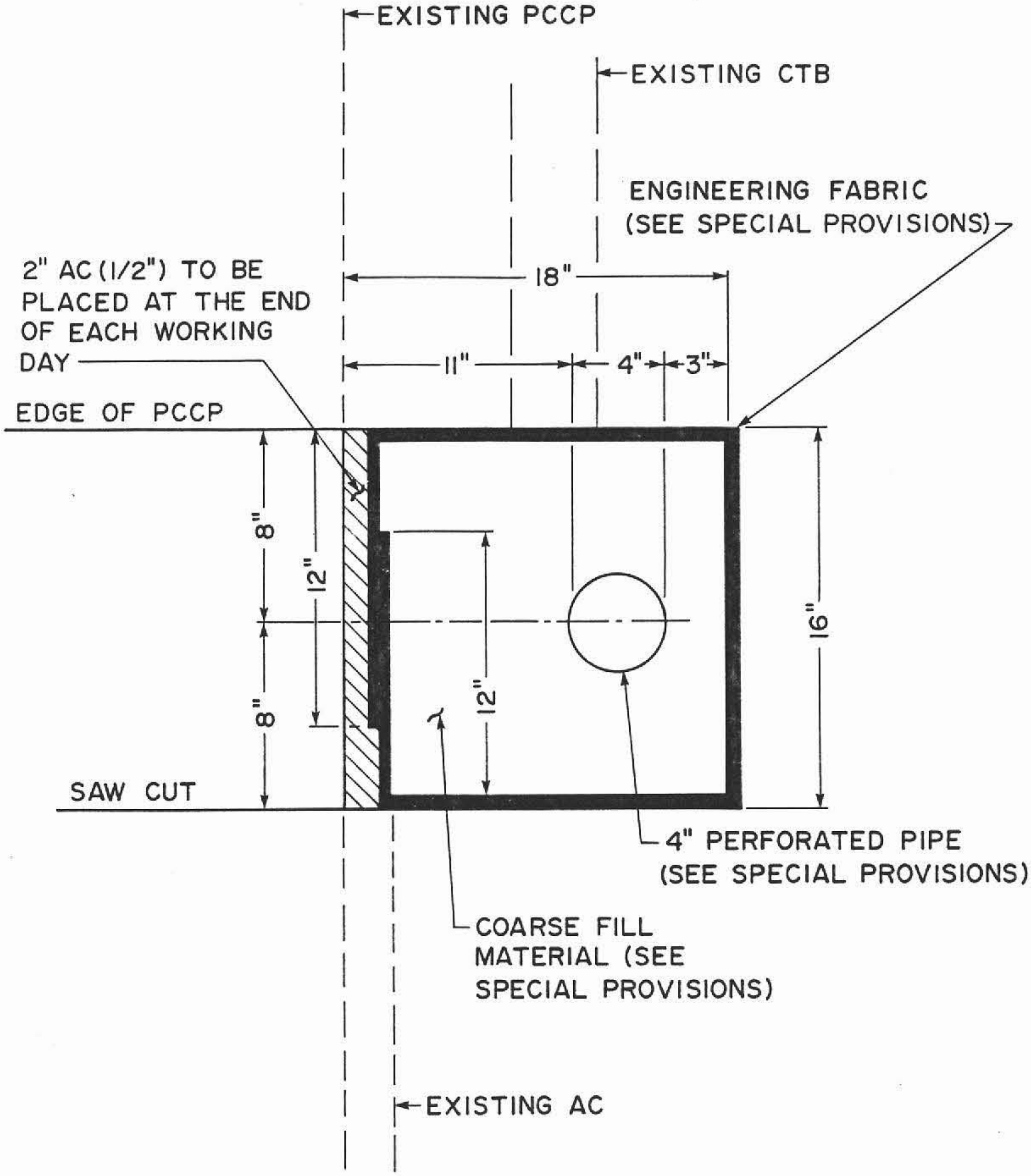


Figure 8 Collector Trench Drainage Design

C. Subgrade Quality and Drainage:

Good subgrade support and drainage are essential to the success of the crack and seat process. Subgrade support influences the optimum size of the cracked pieces. Experience from several states indicate, in general, the better the subgrade support, the larger the size of the cracked pieces. Presence of water in the subgrade will cause loss of subgrade support which leads to rocking of the slabs and subsequent distress in the HMAC overlay.

The quality of the subsurface materials is highly suspect in the same areas that the slabs in the PCCP were in very poor condition. Since many of the broken slabs had not been sealed, water was allowed to intrude into the base materials. To ensure proper drainage, a collector trench was constructed on the edge of the PCCP (Figure 8 shows a typical section of the collector trench). The installation of the subsurface drainage collector system exposed approximately nine inches of the base material and it was observed that free water was frequently present at less than nine inches below the bottom of the slabs.

D. Seating:

Seating is important to provide a stable supporting layer of the HMAC overlay. This process is designed to "seat" the cracked pieces and thus fill any possible voids in the subgrade, resulting in reduction of differential deflections at joints and cracks caused by the voids.

The seating of the cracked PCCP slabs was conducted by rolling the slabs with at least 2 passes of a 50 ton "wagon-like" tire roller filled with sand ballast (Figure 9). Traffic was not allowed on the cracked and seated pavement for about 72 hours, and in general, the bottom 2 inch lift of the HMAC overlay was laid within 72 hours after the crack and seat operations, as per the special provisions.

The crack and seat process was conducted in october 1986, while the placement of the HMAC finished in November 1986.

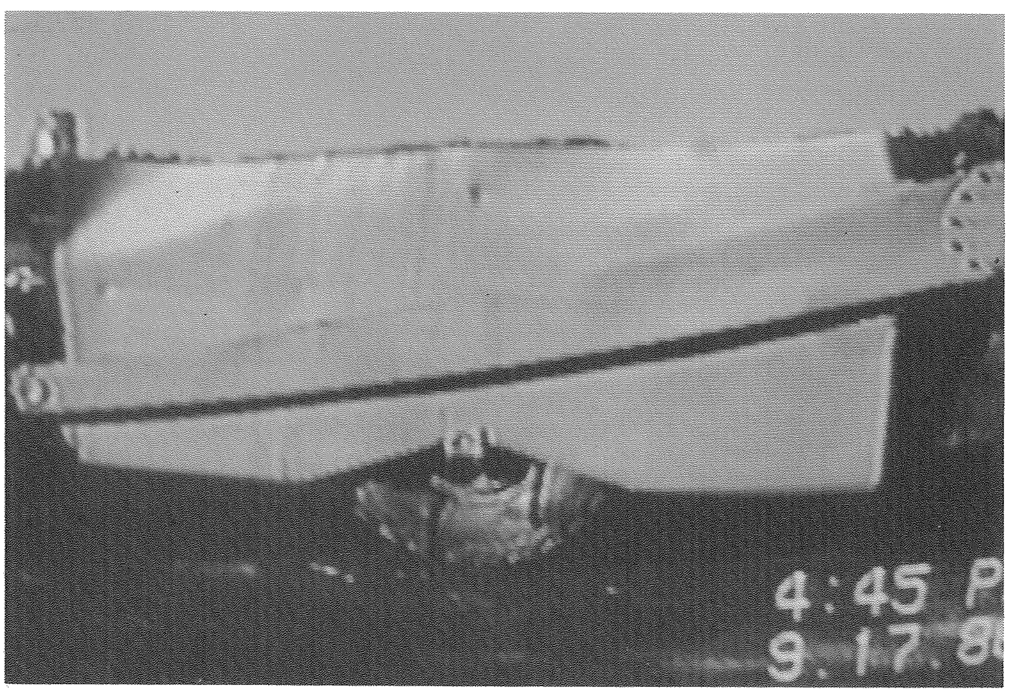


Figure 9 Tire-Roller Used for Seating the Cracked PCCP